Coda wave simulations across the Tyrrhenian Basin using radiative transfer

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The estimation of seismic absorption at regional scale including paths crossing the sea may be affected by different factors. The aim is to characterize the Tyrrhenian basin and its features in term of absorption properties using coda attenuation mapping in a diffusive approximation. As we are considering paths crossing regions characterized by crustal thickeness variations and a shallow Moho, the energy leaked into the mantle and crustal phases corrupting coda attenuation measurements have to be taken into account. Hence, we investigate the effects of crustal thinning on wave propagation in the southern Tyrrhenian basin using radiative transfer theory. We use the software tool Radiative3D (Sanborn Cormier 2018, GJI) to model regional coda envelopes (500-700km).

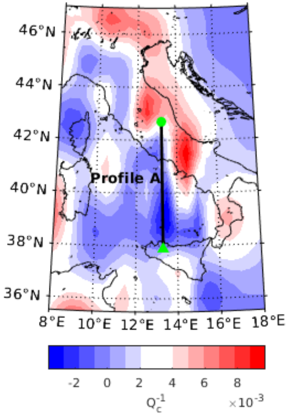

Figure 1 : Q_c^{-1} map in the frequecy band 0.5-1.5Hz. The coda time window is 220-320s. The circle is the source we simulate and the triangle is the receiver. We model the coda envelopes corresponding to this source-station path.

Crust thicknesses are 35 km and 7 km in the unpinched and pinched region, respectively. The 2 km sediments thickness becomes 4 km in the pinch zone. We set low V_p and V_s velocities to represent a column of water. We try to model amplitude variations for the entire seismograms, after filtering at 1 Hz, by varying the crustal thickness. The best fit is shown in Figure 2. If we increase the Moho depth, the phases amplitudes are not recovered.

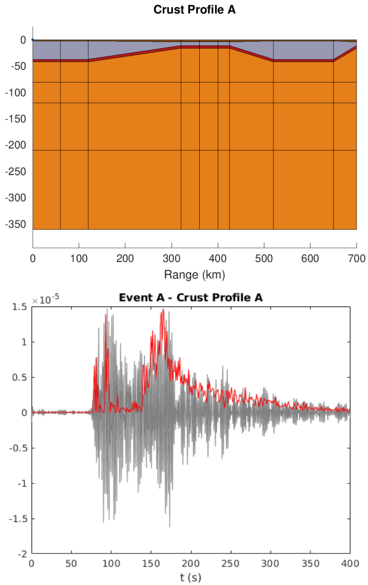

Figure 2: the upper panel shows the setup of the simulation, with meshes representing water, sediments, crustal layer and Moho. The source is located at (0,0). The receiver is at an epicentral distance of 534 km with an azimuth of 175°. In the bottom panel, the gray signal is the real seismogram recorded at that receiver and filtered between 0.5 and 1.5 Hz. The red curve is the synthetic envelope at 1 Hz referred to the path shown in Figure 1.

Exploring different scattering domains (Cormier Sanborn, 2019, BSSA), similar envelopes are obtained using combinations of $\varepsilon^2 a$ equal to a constant. This corresponds to $am \sim 1$, i.e., to heterogeneities size of the same order of the wavelength.

We consider the time interval where the synthetc data corresponding to different scattering domains overlap as the reasonable choice for applying a diffusive approximation. The new map is obtained with coda window starting at $t_w = 270s$ and with a length of $L_w = 80s$.

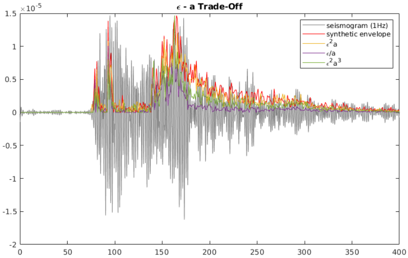

Figure 3: in gray the seismogram filtered between 0.5 and 1.5 Hz. In red we show the synthetic envelope with envelopes corresponding to different scattering domains (yellow: $am \sim 1$, purple: $am >> 1$, green: $am << 1$)

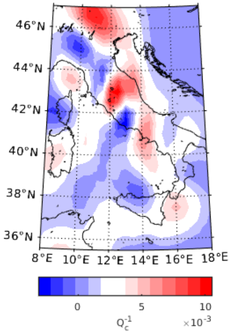

Figure 4: map of intrinsic attenuation obtained by considering a coda window in the estimated diffusive regime.

Conclusions: The forward modelling was motivated by the anomalous results derived from the absorption mapping (Figure 1). The setup of the simulations needs a thin crustal pinch (Figure 2) to fit the real signals. The results obtained by simulating the envelope in different scattering domains indicate a new suitable coda window to compute absorption values.